

**PCT**WORLD INTELLECTUAL PROPERTY ORGANIZATION  
International Bureau

## INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

<b>(51) International Patent Classification <sup>6</sup> :</b> <b>B01D 53/86, F24F 3/16</b>	<b>A1</b>	<b>(11) International Publication Number:</b> <b>WO 98/02235</b> <b>(43) International Publication Date:</b> 22 January 1998 (22.01.98)
<b>(21) International Application Number:</b> PCT/US97/07708 <b>(22) International Filing Date:</b> 6 May 1997 (06.05.97)  <b>(30) Priority Data:</b> 08/695,687 12 July 1996 (12.07.96) US  <b>(71) Applicant:</b> ENGELHARD CORPORATION [US/US]; 101 Wood Avenue, P.O. Box 770, Iselin, NJ 08830-0770 (US).  <b>(72) Inventor:</b> DETTLING, Joseph, C.; 8 Spicy Pond Road, Howell, NJ 07731 (US).  <b>(74) Agents:</b> MILLER, Stephen, I. et al.; Engelhard Corporation, P.O. Box 770, 101 Wood Avenue, Iselin, NJ 08830-0770 (US).		<b>(81) Designated States:</b> AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, FI, GB, GE, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, UZ, VN, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).  <b>Published</b> <i>With international search report.</i>
<b>(54) Title:</b> HEAT EXCHANGE DEVICE AND METHOD OF CATALYTICALLY TREATING THE ATMOSPHERE  <b>(57) Abstract</b>  Method of catalytically activating the surface of a heat exchange device while retaining the heat exchange properties of the device and heat exchange devices obtained thereby.		

**FOR THE PURPOSES OF INFORMATION ONLY**

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakhstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

**HEAT EXCHANGE DEVICE AND METHOD OF CATALYTICALLY TREATING THE ATMOSPHERE**BACKGROUND OF THE INVENTIONField of the Invention

5       The present invention relates to a method for the low temperature cleaning of the atmosphere and more particularly to the rendering of the outer surface of a heat exchanger, such as a radiator of a motor vehicle, capable of catalytically converting pollutants to harmless compounds without adversely  
10 affecting the functioning of the heat exchanger.

Discussion of the Related Art

A review of literature relating to pollution control reveals that the general approach is to reactively clean waste streams entering the environment. If too much of one pollutant  
15 or another is detected or being discharged, the tendency had been to focus on the source of the pollutant. For the most part gaseous streams are treated to reduce the pollutants prior to entering the atmosphere.

It has been disclosed to treat atmospheric air directed  
20 into a confined space to remove undesirable components therein. However, there has been little effort to treat pollutants which are already in the environment; the environment has been left to its own self cleansing systems.

References are known which disclose proactively cleaning  
25 the environment. U.S. Patent No. 3,738,088 discloses an air filtering assembly for cleaning pollution from the ambient air by utilizing a vehicle as in mobile cleaning device. A variety of elements are disclosed to be used in combination with a vehicle to clean the ambient air as the vehicle is driven  
30 through the environment. In particular, there is disclosed

-2-

ducting to control air stream velocity and direct the air to various filter means. The filter means can include filters and electronic precipitators. Catalyzed postfilters are disclosed to be useful to treat nonparticulate or aerosol pollution such as carbon monoxide, unburned hydrocarbons, nitrous oxide and/or sulfur oxides, and the like.

Another approach is disclosed in U.S. Patent No. 5,147,429. There is disclosed a mobile airborne air cleaning station. In particular this patent features a dirigible for collecting air. The dirigible has a plurality of different types of air cleaning devices contained therein. The air cleaning devices disclosed include wet scrubbers, filtration machines, and cyclonic spray scrubbers.

The difficulty with devices disclosed to proactively clean the atmospheric air is that they require new and additional equipment. Even the modified vehicle disclosed in U.S. Patent No. 3,738,088 requires ducting and filters which can include catalytic filters.

Responsive to the difficulties associated with devices with proactively treating the atmosphere, the Assignee herein in U.S. Patent Application Serial No. 08/410,445 filed on March 24, 1995, U.S. Patent Application Serial No. 08/589,182 filed January 19, 1996, and U.S. Patent Application Serial No. 08/589,030 filed January 19, 1996, each incorporated herein by reference, disclosed apparatus in related methods for treating the atmosphere by employing a moving vehicle. In preferred embodiments a portion of the cooling system (e.g. the radiator) is coated with a catalytic or adsorption composition. Additionally, a fan associated with the cooling system can operate to draw or force air into operative contact with the radiator. Pollutants contained within the air such as ozone and/or carbon monoxide are then converted to non-polluting compounds (e.g. oxygen gas and carbon dioxide).

-3-

The Assignee herein also has pending U.S. Patent Application Serial No. 08/412,525 filed on March 29, 1995, incorporated herein by reference, which discloses devices and methods for proactively treating the atmosphere employing a stationary object such as an automobile at rest, a billboard, an air conditioning unit and alike with catalytic composition.

The application of a catalytic composition to the surface of a heat exchange device such as a radiator of a motor vehicle presents problems which can adversely affect the heat exchange properties of the device. For example, the catalytic composition can act as an insulator thereby reducing the ability the radiator to dissipate heat.

It would therefore be a significant advance in the art of reducing pollution to employ heat exchange devices for the treatment of air to remove pollutants without adversely affecting the heat exchange properties of the device. It would be of further advance in the art if this problem could be overcome in an effective and cost efficient manner.

#### Summary of the Invention

The present invention generally relates to a method to treat the atmosphere to remove pollutants therefrom. A heat exchange device such as a radiator of a motor vehicle is treated so that the outer surface thereof catalytically instigates the conversion of pollutants in the atmosphere into harmless compounds without adversely affecting the heat exchange properties of the device. The present invention also encompasses heat exchange devices which can perform in this manner.

The term "atmosphere" is defined herein as the mass of air surrounding the earth. The term "ambient air" shall mean

-4-

the atmosphere which is drawn or forced towards the outer surface of the heat exchange device. It is intended to include air which has been heated either incidentally or by a heating means.

5 In accordance with the present invention, the surface of the heat exchange device must be provided with a substance which can effectively instigate the catalytic conversion of pollutants into harmless compounds. The surface of the heat exchange device must therefore be capable of converting pollutants such  
10 as hydrocarbons, carbon monoxide and ozone into harmless compounds such as oxygen, carbon dioxide and water vapor.

In general, the present invention is directed to a method of catalytically treating the atmosphere to convert pollutants to harmless compounds comprising treating an outer surface of  
15 the heat exchange device to render said surface capable of catalytically converting said pollutants. In one aspect of the invention, the outer surface of the heat exchange device is made of or provided with a catalytically active substance such as a base metal catalyst, precious metal catalyst or combination  
20 thereof. As used herein the terms "base metal catalyst" and "precious metal catalyst" shall include the base metals and precious metals themselves as well as compounds containing the same e.g. salts of precious metals and salts and oxides of base metals. The surface is then treated to increase the surface  
25 area thereof. Surface treatments include contacting the heat exchange device with acid to provide a "pitted" surface having a very high surface area which facilitates the desired catalytic reaction. Optionally the treated outer surface may receive additional catalytic metal by applying a catalytic composition  
30 to a portion of the treated surface.

In an alternative embodiment of the invention, the outer surface is coated with a catalyst composition. However, in order to prevent a reduction in heat exchange capabilities of

-5-

the heat exchange device, the catalyst composition is coated on less than the entire outer surface of the heat exchange device and/or is coated on a surface of the heat exchange device which is not directly engaged in heat exchange activity.

5       The heat exchange device is any device which operates to contact fluids (gases and liquids) having different temperatures so that an exchange of heat is made by the proximity of the two fluids. For purposes of illustration only, the radiator of a motor vehicle is employed herein as a typical example. It will  
10 be appreciated that heat exchange devices are found in air conditioning units and the like are suitable for use in the present invention.

      The ambient air is drawn over the heat exchange device by natural wind currents or by the use of an air drawing means such  
15 as a fan or the like to draw or force ambient air into operative contact with the heat exchange device having the catalytic surface thereon. By way of example, the fan may be positioned in a tunnel, or as part of an air conditioning system or, as previously indicated, preferably in motor vehicles as part of  
20 the conventional cooling system. The fan is typically operated by a power source such as a battery, preferably the conventional twelve volt battery used in a motor vehicle, solar panel and the like. In accordance with a further aspect of the invention, when a catalyst composition is coated on a portion of the heat  
25 exchange surfaces of the heat exchange device and/or on non-heat exchange surfaces, it is desirable to provide a porous, protective coating to protect the catalyst composition from contamination and premature aging through such contaminants as salt, dirt, oil and the like.

30

#### Brief Description of the Drawings

      The following drawings in which like reference characters indicate like parts are illustrative of embodiments of the

-6-

invention and are not intended to limit the invention as encompassed by the claims forming part of the application.

Figure 1 is a side schematic view of a truck showing a grille, air conditioner condenser, radiator, fan and engine;

5        Figure 2 is a perspective view of a radiator of a motor vehicle;

Figure 3 is an enlarged cross-sectional view of a radiator;

10       Figure 4 is a partial front view of a series of corrugated plates of a radiator coated with a catalyst composition in accordance with one embodiment of the present invention;

Figure 5 is a partial front view of a series of corrugated plates of a radiator coated with a catalyst composition in accordance with another embodiment of the invention;

15       Figure 6 is a rear view of a radiator showing the rear surface of the radiator coated with a catalyst composition in accordance with the present invention;

Figure 7 is a partial perspective view of a radiator with fins coated with a catalyst composition in accordance with the present invention; and

20       Figure 8 is a partial front view of corrugated plates of a radiator with the surfaces treated to increase the surface area thereof.

#### Detailed Description of the Invention

25       The present invention is directed to a method of treating the surface of a heat exchange device so that pollutants contained in ambient air may be readily converted to harmless compounds. The surface of the heat exchange device may be rendered catalytic if the surface itself is made of or provided  
30       with catalytically active metals or a catalyst composition may be applied to the surface of the heat exchanger. When a



-7-

catalyst composition is applied to the outer surface of the heat exchanger, it covers only a portion thereof and/or is applied to non-heat exchange surfaces so as to prevent degradation of the heat exchange properties of the heat exchange device. The  
5 present invention is particularly adapted for the conversion of hydrocarbons, ozone and carbon monoxide into harmless compounds such as oxygen, carbon dioxide and water vapor.

The atmosphere contacting surface is the outer surface of a heat exchange device such as a radiator. Any heat exchange  
10 device in which there is a flow of ambient air therethrough may be treated in accordance with the present invention. Of particular importance to the present invention is the rendering of the outer surface of the heat exchange device capable of catalytically converting pollutants to harmless compounds  
15 without adversely affecting the heat exchange activity of the device.

In accordance with one aspect of the present invention, the outer surface of the heat exchange device (e.g. a radiator) is partially coated with a catalyst composition. In particular,  
20 from about 1 to 99 % of the outer surface, preferably from about 25 to 75% is covered with the catalyst composition. To provide the desired partial coating, the non-coated portion can be covered by tape or by a coating containing a material such as Teflon. Useful and preferred catalyst compositions comprise at  
25 least one base metal catalyst and/or at least one precious metal catalyst. The amount of the base metal and the amount of the precious metal may vary and may be tailored to the pollutants contained in the atmosphere. Generally, the base metal catalyst is present in an amount of from about .05 to 5.0 % by weight,  
30 preferably from about .1 to 2.0 % by weight based on the total weight of the catalyst composition. The amount of the precious metal is in the range of up to 20 % by weight, preferably from

-8-

about 0.5 to 10 % by weight based on the total weight of the catalyst composition.

The base metals which may be employed for the catalyst composition include all base metals which can affectively  
5 convert ozone to oxygen and/or carbon monoxide to carbon dioxide. The preferred base metals include iron, copper, chromium, zinc, manganese, compounds containing the same and combinations thereof. The base metals are typically used in the form of oxides.

10 The precious metals are selected from those customarily used in catalysts for the treatment of engine exhaust. The preferred precious metals are platinum, palladium and mixtures thereof. Platinum is the most preferred of the precious metals. In a preferred catalyst composition, the precious metal is  
15 principally dispersed at the surface of the base metal catalyst. This means that at least 50% of the precious metal catalyst is on or close to the surface of the base metal catalyst so as to insure a rapid conversion of the pollutants in the ambient air to harmless by-products.

20 The catalyst composition is also provided with a suitable support material which has a preferably high surface area. The preferred materials are refractory oxides such as those selected from the group consisting of ceria, alumina, titania, silica, zirconia, and mixtures thereof with alumina being the most  
25 preferred refractory oxide support. It is preferred that the refractory oxide support have a high surface area to maximize the amount of the catalytic material within a given unit area. The term "high surface area" as it pertains to the refractory oxide support shall generally mean that the surface area of the  
30 support is at least 100 m<sup>2</sup>/g preferably in the range of from about 100 to 300 m<sup>2</sup>/g.

As previously indicated, the amount of the base metal catalyst and the amount of the precious metal catalyst can vary

-9-

over a wide range. In a preferred catalyst composition, the percent by weight ratio of the precious metal catalyst to the base metal catalyst is at least 1:1. A preferred weight ratio of the precious metal catalyst to the base metal catalyst is in  
5 the range of from about 8:1 to 12:1.

The combination of the base metal and precious metal at the surface thereof provides a catalyst composition which operates at low temperatures to effectively convert carbon monoxide and ozone to harmless by-products.

10 The catalyst composition may be applied to the radiator surface by dipping and/or spraying techniques. In accordance with the present invention, the catalyst composition is coated on less than all of the heat exchange surfaces of the radiator, preferably from about 25 to 75 percent of the radiator surface.

15 As previously indicated, areas of the atmosphere contacting surfaces which are not to be coated may be covered with a material which prevents the catalyst composition from being deposited thereon. Such materials include common tapes (e.g. masking tape) and coating materials such as those  
20 containing Teflon or other material which resists adherence by the catalyst composition.

The covering material is applied to the atmosphere contacting surface followed by the catalyst composition to the areas to be coated. Any of the catalyst composition which  
25 spills over to the non-coated areas may be removed, for example, by removing the covering material.

The pattern of application of the catalyst composition is virtually unlimited so long as the catalyst composition covers less than the entire heat exchange surface of the heat exchange  
30 device. For example, the catalyst composition can be applied in spaced-apart rows extending the length of heat exchange device. Alternatively, the catalyst composition can be applied to portions of opposed sides of the heat exchange device.

-10-

In another aspect of the invention, the catalyst composition may be applied to non-heat exchange surfaces of the heat exchange device. "Non-heat exchange surfaces" means that these surfaces do not engage in heat exchange between respective  
5 fluids. When applied to said surfaces, there is obviously no interference with the heat exchange properties of the device. Accordingly, the non-catalytic surfaces can be coated up to their entirety with the catalyst composition if desired. Examples of non-catalytic surfaces of heat exchanges include the  
10 rear or back surfaces and extensions of the heat exchange device (e.g. fins and the like) which are not in contact with the heat-exchange fluids passing therethrough.

The heat exchange surfaces of the heat exchange device can be rendered catalytic if the surface itself is made of or  
15 provided with catalytically active substances (e.g. base metals alone or in combination with minor amounts of precious metals). In order to provide an effective catalytic surface, the surface area of the typical heat exchange device is desirably increased. This can be accomplished by treating the surface of the heat  
20 exchange device with an acid to provide a "pitted" outer surface. The thus treated heat exchange device can provide an effective system for catalytically converting pollutants to harmless compounds. Because there is no catalyst composition applied to the heat exchange surfaces in this embodiment, the  
25 acid treatment may be applied to the entire surface of the heat exchange device or only a portion thereof.

A non-catalytic surface of the radiator may be rendered catalytic by applying base metals alone or in combination with precious metals to the radiator surface. The catalytic metals  
30 may be applied by vaporizing the metal and depositing the vaporized metal on the radiator surface.

It should be understood, however, that in some cases it is desirable to add a catalyst composition to the pitted surfaces

-11-

to improve conversion rates. The same type of catalyst compositions as previously described may be used. In this event, the heat exchange surfaces of the heat exchange device must not be covered in their entirety in order to prevent  
5 degradation of heat exchange properties.

In operation of the present invention, air is drawn or forced over the catalytic surface by natural wind currents or by air drawing devices such as fans. For land use motor vehicles, the heat exchange surfaces are preferably those of the radiator.  
10 It should be understood, however, that other heat exchange devices such as air conditioning condensers and the like may be treated in a like manner.

In a most preferred embodiment of the present invention, the atmosphere contacting surfaces are appropriate surfaces of a  
15 radiator. By treating the radiator surface as described herein pollutants can be readily removed from the atmosphere without compromising the heat exchange properties of the radiator.

The present invention will be understood by those skilled in the art by reference to accompanying Figures 1-8. The  
20 present invention can be applied to heat exchange devices of any type and to both heat exchange and non-heat exchange surfaces. What is particularly important in accordance with the present invention is that the heat exchange characteristics of the heat exchange device be maintained. As the ambient air encounters  
25 the catalytic surface of the heat exchange device, hydrocarbons, carbon monoxide and/or ozone are catalytically reacted to produce harmless by-products such as oxygen, carbon dioxide, and water vapor.

It will be appreciated by those skilled in the art that  
30 when the heat exchanger is associated with a vehicle, any suitable vehicle can be employed. Vehicles include cars, trucks, trains, boats, ships, airplanes, dirigibles, balloons, and the like. Preferably in a motor vehicle, the atmosphere

-12-

contacting surfaces are surfaces located toward the front of the vehicle in the vicinity of the cooling system fan. Useful contact surfaces include the outside surfaces of the radiator, air conditioner condenser, and the like which are all located  
5 and supported within the housing of the vehicle.

Figure 1 illustrates a truck 10 schematically containing a variety of vehicle components wherein a radiator or air conditioner condenser comprise atmosphere contacting surfaces. The vehicle includes a grille 12, an air conditioner condenser  
10 14, a radiator 16 and a radiator fan 18. It will be understood that other vehicle components can be found in the truck.

Referring to Figures 1 and 2, the preferred atmosphere contacting surfaces include the front 13 and side 15 surfaces of the air conditioning condenser 14, the front 17 and side 19  
15 surfaces of the radiator 16. These surfaces are located within the housing 24 of the truck. They are typically under the hood of the truck between the front 26 of the truck and the engine 28. The air conditioner condenser 14 and the radiator 16 can be directly or indirectly supported by the housing 24 or a frame  
20 (not shown) within the house.

Figure 2 generally shows a schematic view of a radiator-air conditioning condenser assembly. The automobile comprises a housing 30. There is a front end 32 of the motor vehicle having a grille 12 supported on the front of the housing 30. An air  
25 conditioner condenser 14, a radiator 16 and a radiator fan 18 can be located within the housing 30.

The surfaces of the air conditioner condenser 14 and the radiator 16 can be treated in accordance with the present invention to provide a catalytic surface without adversely  
30 affecting the heat exchange properties of the devices. The most preferred atmosphere contacting surface is the outer surface of the radiator 16. A typical radiator has front and rear surfaces with spaced apart flat tubes having therebetween a plurality of

-13-

radiator corrugated plates. More specifically and referring to Figure 3, there is shown a radiator 18 including spaced apart tubes 40 for the flow of a first fluid and a series of corrugated plates 42 therebetween defining a pathway 44 for the flow of a second fluid transverse to the flow of the first fluid. The first fluid such as antifreeze is supplied from a source (not shown) to the tubes 40 through an inlet 46. The antifreeze enters the radiator 18 at a relatively low temperature through the inlet 46 and eventually leaves the radiator through an outlet 48. The second fluid such as air passes through the pathway 44 and thereby comes into heat exchange relationship with the first fluid passing through the tubes 40.

In accordance with the present invention, the surfaces of the corrugated plates 42 of the radiator 18 can be treated to provide a catalytic surface which does not interfere with the heat exchange properties of the radiator. In one embodiment of the invention, the catalyst composition is coated on the corrugated plates 42 in space-apart rows. Referring specifically to Figure 4, there is shown an embodiment of the invention wherein alternating corrugated plates 42 are coated with a catalyst composition for removing pollutants from the atmosphere. As shown specifically in Figure 4, surfaces 42a, 42c, 42e, 42g and 42i are coated with the catalyst composition while surfaces 42b, 42d, 42f, 42h and 42j are not. As a consequence, the radiator 18 is provided with catalytic surfaces capable of converting pollutants to harmless compounds while, at the same time, capable of performing its heat exchange function in a efficient manner through the exposed, non-coated surfaces.

In another embodiment of the invention, the catalyst coating is applied to all of the corrugated surfaces but only on a portion thereof. Referring to Figure 5, each of plates 42 are coated on a portion of the surface thereof to provide a

-14-

catalytic surface 42j and a non-catalytic surface 42k. In this embodiment, each corrugated plate provides a catalytic surface for the conversion of pollutants to harmless compounds while enabling the radiator to perform its heat exchange function  
5 through all of the corrugated plates.

In accordance with the present invention, non-heat exchange surfaces of the radiator or other heat exchange devices may be coated with the catalyst composition without interfering with the heat exchange properties of the device. In particular,  
10 non-heat exchange surfaces of the radiator may be coated with the catalyst composition and/or non-heat exchange extension may be added to the heat exchange device and coated with the catalyst composition.

Referring to Figure 6, there is disclosed a view of a  
15 radiator including a housing 50 and corrugated plates 42 in which the rear surfaces 52 of the corrugated plates 42 are coated with the catalyst composition. The rear surfaces 52 are non-heat exchange surfaces because ambient air passing into contact with the rear surfaces has already been cooled by the  
20 cooling fluid and therefore heat exchange is not occurring at the rear end of the radiator.

In another embodiment of the invention as shown in Figure 7, the radiator is provided with at least one, preferably a plurality of projections 60 (e.g. fins) which are non-heat  
25 exchange surfaces. The fins 60 are coated with the catalyst composition in a customary manner (e.g. by spraying). When in contact with ambient air, the surfaces of the fins, heated via conduction from the heat exchange surface, are capable of catalytically converting pollutants contained within the air to  
30 harmless compounds.

In another aspect of the present invention, the surface of the radiator may be treated to provide a catalytic surface without coating the same with a catalytic composition.



-15-

Radiators made of metals which are capable of catalytically converting hydrocarbons, carbon monoxide and/or ozone to harmless compounds may be used in this embodiment. In order to provide a suitable catalytical surface, it is essential that the surface area of the radiator being increased. This can be done in any manner which roughens the surface of the radiator. Referring to Figure 8, a preferred way of treating the outer surface of the radiator is to contact the same with a metal capable of reacting with the acid to form a roughened surface. The roughening of the surface provides a series of spaced apart pits or depressions which dramatically increase the surface area of the radiator thereby providing an adequate number of catalytic sites for the pollutant conversion reactions.

The acids which can be used to treat the metals include mineral acids such as hydrochloric acid, sulfuric acid, phosphoric acid and the like. Organic acids such as acetic acids, formic acid and the like may also be used.

The acid may be applied to the radiator by dipping, spraying, brushing and the like. The amount of acid which is used and the duration of the treatment is within the routine skill of the art and is sufficient to provide a noticeable increase in the surface area of the radiator without damaging the heat exchange properties of the radiator.

In each embodiment described above a porous protective coating may be provided to the catalytic surface. The protective coating contains a protective substance which is stable at temperatures up to 100°C and is resistant to chemicals, salts, dirt and other contaminants which may adversely affect the catalyst composition. Plastic materials meeting this criteria are known and include polyethylene, polypropylene, polytetrafluoroethylene (e.g. Teflon) and the like. Polytetrafluoroethylene is a preferred material for the protective coating.

-16-

The protective coating may be applied by dipping and spraying techniques. A preferred method of application is to use a non-halogen containing aerosol spray.

-17-

What is Claimed:

1. A method of catalytically treating the atmosphere to convert pollutants to harmless compounds comprising treating an outer surface of a heat exchange device to render said surface capable of catalytically converting said pollutants without adversely affecting the heat exchange properties of the heat exchange device.
2. The method of Claim 1 wherein the outer surface comprises at least one catalytically active metal, said process comprising increasing the surface area of the outer surface of the heat exchange device.
3. The method of Claim 2 comprising treating the outer surface of the heat exchange device with an acid in an amount sufficient to roughen at least a portion of the outer surface.
4. The method of Claim 2 wherein the metal of the outer surface is selected from the group consisting of base metals, precious metals and combinations thereof.
5. The method of Claim 3 wherein the acid is selected from the group consisting hydrochloric acid, sulfuric acid, phosphoric acid and organic acids.
6. The method of Claim 3 further comprising depositing a catalytic metal on at least a portion of the treated outer surface of the heat exchange device.
7. The method of Claim 6 where the step of depositing the catalytic metal on the heat exchange device comprises vaporizing a metal and depositing said metal on the outer surface of the heat exchange device.

-18-

8. The method of Claim 1 comprising applying a catalytic composition to a portion of the outer surface area of the heat exchange device.

9. The method of Claim 8 comprising applying the catalytic composition to from about 1 to 99% of the outer surface of the heat exchange device.

10. The method of Claim 9 comprising applying the catalytic composition to from about 25 to 75% of the outer surface of the heat exchange device.

11. The method of Claim 8 comprising applying a coating of catalyst composition containing a catalytic component selected from the group consisting of base metals, precious metals, compounds thereof and combinations thereof to a portion of the outer surface of the heat exchange device.

12. The method of Claim 8 wherein the catalyst composition contains from about 0.05 to 5.0% by weight of a base metal catalyst and up to about 20% by weight of a precious metal catalyst, based on the total weight of the catalyst composition.

13. The method of Claim 11 wherein at least 50% of the precious metal catalyst is on or close to the surface of the base metal catalyst.

14. The method of Claim 8 comprising applying the catalytic composition in spaced apart rows to the heat exchange device.

15. The method of Claim 8 wherein the heat exchange device contains a plurality of corrugations, said method

-19-

comprising applying the catalytic composition to a portion of each of the corrugations.

16. The method of Claim 12 wherein the % by weight ratio of the precious metal catalyst to the base metal catalyst is at least 1:1.

17. The method of Claim 1 wherein the heat exchange device comprises a non-heat exchange outer surface, said process comprising treating at least a portion of the non-heat exchange surface with a catalytic composition.

18. The method of Claim 1 further comprising applying a protective coating to the outer surface of the heat exchange device.

19. The method of Claim 18 wherein the protective coating contains at least one protective substance which is stable at temperatures up to 100°C and is resistant to contaminants which can adversely affect the treating step.

20. The method of Claim 19 wherein the protective substance is selected from the group consisting of polyethylene, polypropylene and polytetrafluoroethylene.

21. The method of Claim 19 comprising spraying the protective substance as an aerosol onto the outer surface of the heat exchange device.

22. A heat exchange device comprising an outer surface having at least a portion of the outer surface treated to render said surface capable of catalytically converting pollutants in

-20-

ambient air to harmless compounds without adversely affecting the heat exchange properties of the heat exchange device.

23. The heat exchange device of Claim 22 comprising an acid treated outer surface.

24. The heat exchange device of Claim 22 comprising a heat exchange outer surface, a portion of said heat exchange outer surface being coated with a catalyst composition.

25. The heat exchange device of Claim 22 comprising a non-heat exchange outer surface, at least a portion of said non-heat exchange outer surface coated with a catalyst composition.

26. The heat exchange device of Claim 24 wherein the heat exchange outer surface is coated with a plurality of spaced apart rows of the catalyst composition.

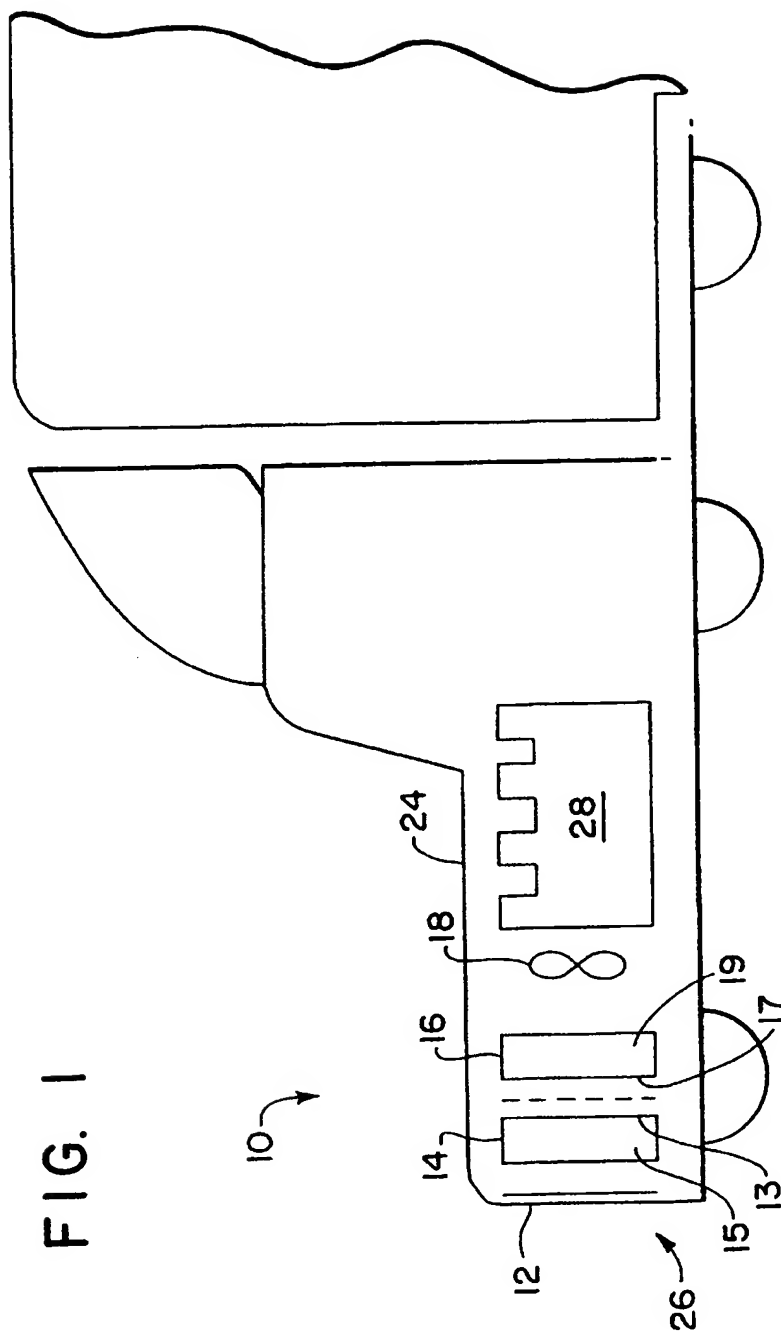
27. The heat exchange device of Claim 24 comprising a plurality of corrugations, said catalyst composition being coated on a portion of each of the corrugations.

28. The heat exchange device of Claim 22 further comprising a protective coating on the outer surface.

29. The heat exchange device of Claim 28 wherein the protective coating contains at least one protective substance which is stable at temperatures up to 100°C and is resistant to contaminants which can adversely affect said surface catalyst composition.

-21-

30. The heat exchange device of Claim 29 wherein the protective substance is selected from the group consisting of polyethylene, polypropylene and polytetrafluoroethylene.





2 / 3

FIG. 3

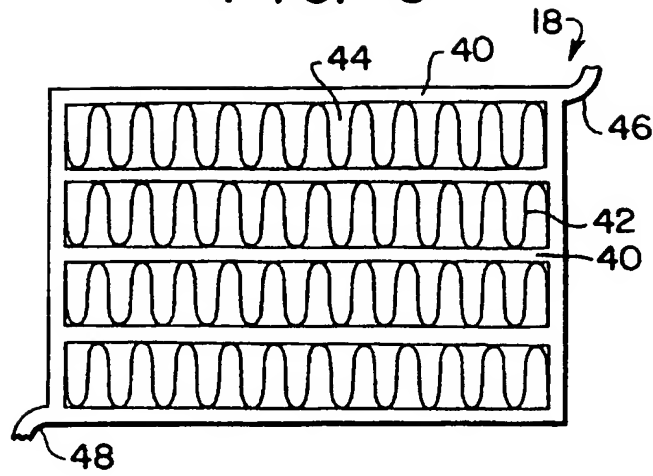


FIG. 4

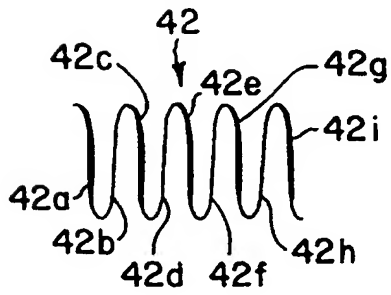


FIG. 5

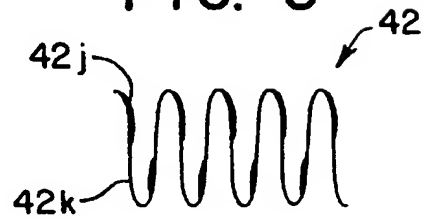


FIG. 2

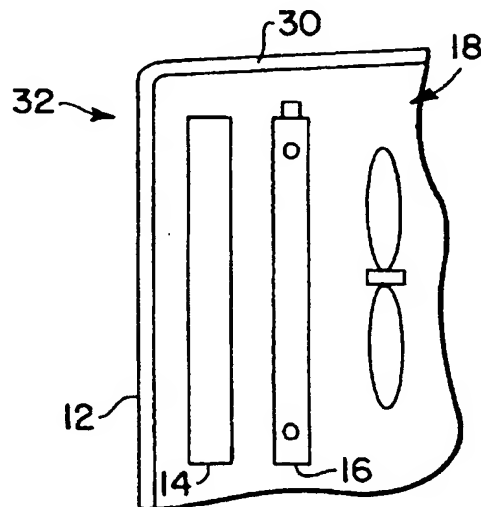


FIG. 6

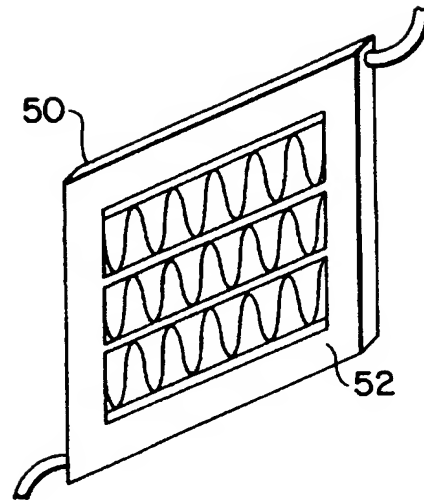


FIG. 7

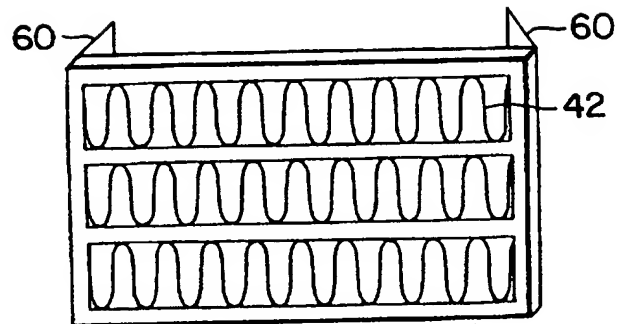
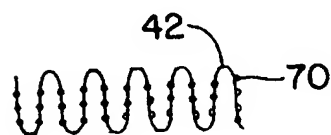


FIG. 8



# INTERNATIONAL SEARCH REPORT

International Application No  
PCT/US 97/07708

A. CLASSIFICATION OF SUBJECT MATTER  
IPC 6 B01D53/86 F24F3/16

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)  
IPC 6 B01D F24F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X, L	WO 96 22146 A (ENGELHARD CORP ;HOKE JEFFREY B (US); NOVAK JOHN R (US); STEGER JOH) 25 July 1996 see the whole document ---	1-30
P,X, L	WO 96 22148 A (ENGELHARD CORP ;DETLING JOSEPH C (US); STEGER JOHN J (US); SPENCE) 25 July 1996 see the whole document ---	1-30
P,X, L	WO 96 22149 A (ENGELHARD CORP ;HOKE JEFFREY B (US); NOVAK JOHN R (US); STEGER JOH) 25 July 1996 see the whole document ---	1-30
	--- -/--	

☒ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

### \* Special categories of cited documents :

- \*A\* document defining the general state of the art which is not considered to be of particular relevance
- \*E\* earlier document but published on or after the international filing date
- \*L\* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- \*O\* document referring to an oral disclosure, use, exhibition or other means
- \*P\* document published prior to the international filing date but later than the priority date claimed

- \*T\* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- \*X\* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- \*Y\* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- \*G\* document member of the same patent family

Date of the actual completion of the international search

14 August 1997

Date of mailing of the international search report

02.09.97

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2  
NL - 2280 HV Rijswijk  
Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,  
Fax (+31-70) 340-3016

Authorized officer

Kanoldt, W

# INTERNATIONAL SEARCH REPORT

International Application No

PCT/US 97/07708

## C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X, L	WO 96 22150 A (ENGELHARD CORP ;POLES TERENCE C (US); ROSENBERG WILLIAM G (US); CA) 25 July 1996 see the whole document ---	1-30
X	EP 0 186 477 A (GARRETT CORP) 2 July 1986 see claims 1-5; figures 1,2 ---	1,22
X	DE 33 34 992 A (DAIMLER BENZ AG) 25 April 1985 see claims 1,2; figure 1 ---	1,22
X	EP 0 097 287 A (SUEDEDEUTSCHE KUEHLER BEHR ;SORBEXX GMBH (DE)) 4 January 1984 see claims 1-17; figures 1-4 ---	1,22
X	DE 40 07 965 A (HAGER KLAUS) 19 September 1991 see column 1, line 2 - column 2, line 18; figures 1,2 ---	1,22
A	EP 0 351 036 A (CORNING GLASS WORKS) 17 January 1990 ---	1-30
A	US 5 145 822 A (FALKE HOLGER ET AL) 8 September 1992 ---	1-30
A	US 5 283 041 A (NGUYEN PASCALINE H ET AL) 1 February 1994 -----	1-30

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/07708

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9622146 A	25-07-96	AU 4701196 A	07-08-96
		AU 4764296 A	07-08-96
		AU 4900296 A	07-08-96
		AU 4964796 A	07-08-96
		WO 9622148 A	25-07-96
		WO 9622149 A	25-07-96
		WO 9622150 A	25-07-96
		AU 7201896 A	17-04-97
		WO 9711769 A	03-04-97
-----			
WO 9622148 A	25-07-96	AU 4701196 A	07-08-96
		AU 4764296 A	07-08-96
		AU 4900296 A	07-08-96
		AU 4964796 A	07-08-96
		WO 9622149 A	25-07-96
		WO 9622150 A	25-07-96
		WO 9622146 A	25-07-96
		AU 7201896 A	17-04-97
		WO 9711769 A	03-04-97
-----			
WO 9622149 A	25-07-96	AU 4701196 A	07-08-96
		AU 4764296 A	07-08-96
		AU 4900296 A	07-08-96
		AU 4964796 A	07-08-96
		WO 9622148 A	25-07-96
		WO 9622150 A	25-07-96
		WO 9622146 A	25-07-96
		AU 7201896 A	17-04-97
		WO 9711769 A	03-04-97
-----			
WO 9622150 A	25-07-96	AU 4701196 A	07-08-96
		AU 4764296 A	07-08-96
		AU 4900296 A	07-08-96
		AU 4964796 A	07-08-96
		WO 9622148 A	25-07-96
		WO 9622149 A	25-07-96
		WO 9622146 A	25-07-96
		AU 7201896 A	17-04-97
		WO 9711769 A	03-04-97
-----			

# INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 97/07708

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0186477 A	02-07-86	US 4665973 A JP 61153428 A	19-05-87 12-07-86
DE 3334992 A	25-04-85	US 4824363 A	25-04-89
EP 0097287 A	04-01-84	DE 3222983 A JP 59007897 A	22-12-83 17-01-84
DE 4007965 A	19-09-91	NONE	
EP 0351036 A	17-01-90	US 4888317 A AU 624622 B AU 3811289 A CA 1315526 A CN 1039541 A JP 2071846 A	19-12-89 18-06-92 18-01-90 06-04-93 14-02-90 12-03-90
US 5145822 A	08-09-92	DE 4017892 A EP 0461452 A ES 2043407 T JP 5192585 A	05-12-91 18-12-91 16-12-93 03-08-93
US 5283041 A	01-02-94	AT 146697 T DE 69306956 D DE 69306956 T EP 0655014 A JP 8500055 T WO 9404251 A	15-01-97 06-02-97 26-06-97 31-05-95 09-01-96 03-03-94